DESIGN OF STEAM-ELECTRIC GENERATING STATION FOR DETROIT, MICH.

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OF A
30000 K.W. STEAM-ELECTRIC GENERATING STATION
FOR
DETROIT, MICHIGAN.

A THESIS

PRESENTED BY

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INTRODUCTION

In designing a 30,000 K. W. Steam-Electric Generating Station for Detroit, Mich., the authors have not attempted to design any particular machine or device, but have undertaken to provide, by selection from various makes already on the market, an assemblage of machines and devices, each designed to perform its particular function in the most economical manner, and to combine them so as to create one complete unit for the purpose of generating electricity from coal on a commercially satisfactory basis. The problems involved in the design of this station are as follows:-

A. Determination of total generating capacity of station.

B. Selection of site for the station.

C. General layout of station.

D. Determination of size, number, and type of generators.

E. Determination of size, number, and type of boilers.

F. Coal and Ash handling.

G. Determination of size, number, and arrangement of chimneys.

H. Arrangement of turbines and their auxiliaries.

I. Piping

J. Selection of voltage and frequency of generators.

K. Excitation.

L. Selection of Switch house equipment and its arrangement.

M. Estimate of total cost of station.

DETERMINATION OF THE TOTAL GENERATING CAPACITY OF A STATION.

In the determination of the total generating capacity of a station, several conditions must be considered; first, the existing load, and second, the possible growth and progress of the supplied locality, since the amount of power required at any time varies with the population. If the power receiving district is so situated, as to become a manufacturing center, this should be considered, since electricity is superseding steam drive in factories and for certain railway service, on account of its flexibility.

The load curve from which the capacity of the station was determined is shown on the accompanying blue print. The designers deemed it advisable to make the rated capacity of the station 30,000 K. W. rather than 27,500 K. W., which was the maximum load as indicated by the load curve.

SELECTION OF SITE

In selecting a site for a large central station, the engineer is confronted by several problems; first, facilities for freight handling, coal delivery and removal of cinders. The plant should be located near

a railway which can transport sufficient fuel at justifiable rates, or near a ship canal with ample docking space for coal carrying vessels.

There must be available ground adjacent to the station, to permit the storage of coal for tiding over a certain period in case of strikes at the mines or on the railroads. The storing space should be so situated as to require a minimum of conveying and coal handling apparatus. Second, an unlimited supply of suitable condensing water must be provided, the temperature of which will not be excessive during the summer time. The water should be free from sewage, seaweeds and other debris; and the proposed location for the station should be such, that the intake and discharge tunnels be as short as possible and the lift to the condenser as small as possible. Thirdly, a satisfactory location with a low valuation must be found which is reasonably near the bulk of business. The land acquired should be of sufficient area, to provide for future expansion and against the crowding of power plant equipment. In selecting the site the character of the soil must be well considered with reference to its bearing capacity to avoid expensive pile driving and large foundation expense.

The Detroit Light and Power Station is loca-

ted on the north bank of the Detroit River at the foot of Meldrum Avenue and is about two and one-half miles from the business center of the city of Detroit. This location affords an unlimited supply of water with short intake and discharge tunnels, and the extent of property is sufficient to allow ample storage capacity for coal. The Transit railway, which makes connections with the Lake Shore & Michigan Southern, Michigan Central and Grand Trunk railways, extends into the property, giving excellent facilities for the transportation of coal, ashes and heavy machinery. The soil is principally sand with a bed of clay underneath, so that the heaviest construction called for in the building of the station can be carried on ordinary footings without the use of piles.

GENERAL LAYOUT OF STATION

The superstructure of the plant is of skeleton steel constructed to carry the various floors, bunkers and boilers, it rests on a foundation of 1 beams and concrete. The walks are of red pressed brick trimmed with Bedford Stone. The building as a whole is divided into four parts. These are as follows:-

(1) The train shed.

(2) The boiler room.

(3) The turbine room.

(4) The switch house.

The station arrangement is longitudinal; that is, the four divisions extend the entire length of the building and parallel to each other. With this layout if it is necessary to enlarge the plant, it can be done without making alteration on the old building, or interfering with the generating equipments. The advantage of this system is not in a reduction of space required but in providing better light and ventilation, a more serviceable and easily operated coal and ash handling system and a more simple and flexible piping system. The space required by this arrangement is 1.8 square feet per K. W. This value is well within the limits when compared with the floor space required per K. W. by the present generating station. The train shed is nearest the river, then follow the parts of the station as enumerated in the foregoing.

The train shed is 274 feet long, 25 feet wide and 54 feet high. A railway track is laid throughout the entire length of the building, thereby enabling coal cars to pass through the building. An overhead traveling crane with a grab bucket is employed in unloading coal into the coal bunkers. In the basement of the train shed are the coal conveyors and crushers.

The boiler room is 71 feet wide and 64 feet high including the basement. The walls have an eight foot

wainscoting of enameled brick, the remainder being red pressed brick. The boilers are arranged in two rows, with one firing aisle. The boiler settings are placed about five feet apart, to allow space for repairing. Lighting and ventilation is done from monitors with glass sides and roof. A five ton hand crane is used in the boiler room. The basement of the boiler room contains the ash and fine coal hoppers, conveyors, and steam and boiler freed piping.

The turbine room is 52 feet wide and 66 feet high. To add to the architectural appearance of the interior, and also to facilitate the work of keeping the room neat and clean, it is finished with tile and enameled brick. The floor is of concrete covered with hexagonal terra cotta tile. A 60 ton motor driven crane spans the turbine room. The crane track is concealed by the wall finish. A railway track is laid on the turbine floor so that heavy machinery can be delivered directly to the turbine room. A monitor with glass sides and roof in connection with the windows in the end walls provide good ventilation and light.

The switch house is 37 feet wide and 40 feet high. It is divided into three parts, the cable passage, burbar compartments and oil switch room. A more detailed discussion of the switch house will be given under the

switch house will be given under the heading of switch equipment and arrangement.

DETERMINATION OF SIZE, NUMBER AND TYPE OF GENERATING UNITS.

From the form of the load curve it was deemed advisable to use five units, each having a capacity of 6,000 K. W. These units are of the Curtis vertical turbo-generator type. The units are used as follows:-

1 unit from midnight to 5:00 A. M.

2 units from 5:00 A. M. to 6:00 A. M.

3 units from 6:00 A. M. to 7:00 A. M.

4 units from 7:00 A. M. to 9:00 P. M.

3 units from 9:00 P. M. to 11:00 P. M.

2 units from 11:00 P. M. to 12:00 P. M.

1 unit is held in reserve and is to take the place of some unit which may be out of order or undergoing repairs.

Before determining upon the apparatus to be installed in the station, careful consideration was given to the relative merits of turbines and reciprocating engines as prime movers. The advantages of the turbine over the engines in first cost, lesser amount of help required to operate, a saving in floor space, simplicity, and the absence of oil in the condensed steam, thus allowing the condensed steam to be used

feed water decided the question in favor of the turbines. Another important feature in favor of the turbines is its ability to start idle units quickly. The presence of an abundant supply of suitable condensing also influenced the selection of turbines.

DETERMINATION OF SIZE, NUMBER AND TYPE OF BOILERS.

In selecting the type of boiler, the respective merits were considered with reference to durability, accessibility for repairs; facility for cleaning and inspection; capacity, and space requirement. On account of the high pressure and temperature, the water tube type was considered safer than the fire tube, because the shell plates and seams of the latter must be of considerable thickness in large units, and being exposed to the hottest part of the fire are likely to give trouble, especially if the water contains impurities. The type of boiler having the foregoing requirements and because of the satisfaction which Babcock and Wilcox boilers have given in large central stations, this type of boiler was selected.

The boiler plant is divided into two sections each section consisting of fourteen, 500 horsepower boilers equipped with B. & W. chain grates. The settings are installed face to face as shown on the

accompanying blueprint. Each boiler has two 42 inch steam drums, approximately 5,000 square feet of heating surface and about 1,000 square feet of superheating surface. The entire boiler is enclosed in a casing of steel to prevent air leakage. Steam is generated at a pressure of 180 pounds per square inch, with a superheat of 150°F. The amount of superheat was made conservative to be sure that the temperature would not cause trouble with flanged joints and in the steam cylinders of the auxiliaries.

COAL AND ASH HANDLING.

Coal is brought in to the train shed on cars and is dumped or unloaded by grab buckets into the track hoppers, from which it is delivered by conveyors to one of two crushers, which are to be used in case lump coal is furnished. Transverse belt conveyors carry the coal to two longitudinal conveyors, these deliver the coal to the overhead bunkers of 80 tons capacity. The coal bunkers feed through flexible down spouts to the stoker magazines. Underneath the front of the stokers are the fine coal hoppers which collect the fine coal that falls through the grate and discharges into the coal conveyor. The ashes are collected in the ash hoppers and are discharged into the coal conveyor, which carries them to the ash bins located at

each end of the boiler room, from here they are delivered to an ash bin directly over the coal track in the train shed. The conveyors are of the McCaslin pattern, endless chain with overlapping buckets, each bucket having a capacity of about 100 pounds.

DETERMINING SIZE, NUMBER AND ARRANGEMENT OF CHIMNEYS.

Steel chimneys have many advantages and are finding much favor in large power plants, especially where economy of space is required. In which case the structural work of the boiler settings answer for boiler and chimney. The low first cost, small space required and the ease and rapidity of construction favored the selection of the steel type of chimney.

One stack is provided for each section of seven boilers. The shaft is supported by the steel work of the boiler settings. Each stack is 10 feet in diameter and 250 feet in height above the grate surface. The lining is radial fire brick and varies in thickness from four inches to twelve inches. There are two flues which enter the stack from opposite sides each 46 feet long.

ARRANGEMENT OF TURBINES AND THEIR AUXILIARIES.

Extending down the center line of the turbine room is a row of five turbo-generators with their

auxiliaries. Each unit has a continuous rating of 6,000 K. W. and is a complete and individual unit, each with its own auxiliaries. The distance from center to center of these machines is alternately 50 and 52 feet.

The turbines are five stage machines with Worthington base condensers. The condensers are set in the basement so that the operating parts of the turbine are conveniently reached from the main turbine floor. The base condenser was adopted because an unlimited supply of condensing water was available and on account of giving a somewhat better vacuum in the turbine, which is an important consideration in turbine work. It also reduces the floor space required for installing, simplifies the piping and makes possible a pleasing arrangement of machinery.

Ventilation of the turbo-generators is accomplished by using large ventilating ducts, which lead to the top of the generator. These ducts are connected to air chambers in the basement, and as vaner are placed in the incased revolving field cover of the generators air is drawn through these ducts to ventilate the generators. The heated air is forced downward and out through the laminations of the stationary armatures and rises to the top of the turbine room, where it

escapes to the outer air by means of the monitors.

The condensing apparatus has 14,000 square feet of condensing surface and is designed to condense 99,000 pounds of steam per hour with a vacuum of 28 inches of mercury using cooling water at summer temperature. The same apparatus under winter conditions will give a vacuum within three quarters of an inch of the barometer. Each condenser is equipped with a combined circulating and vacuum pump driven by a Corliss engine. The pump is of the volute centufugal type and has a rating of 17,000 gallons per minute. The quantity of water to be handled being very great and the head very low, the volute centufugal pump is very well adopted for this duty. Each unit is also provided with a four inch two stage turbine hot well pump, which is set in the basement next to the condenser. Also each unit has an independent vertical feed water heater. Three duplex boiler feed pumps are used for each two units. The third pump is used in case of fire or break down of the other pumps. The boiler feed water is taken either from the hot well or from the intake tunnel.

A double oiling system is provided for each unit. One system supplies oil to the step bearing at a pressure of 1,200 pounds per square inch. The other system supplies oil to the upper and intermediate bearings of the turbo-

generator and to the governor. Each unit is equipped with two step bearing pumps. To obviate fluctuations in the pressure due to the pump reversing its stroke, an oil accumulator is used. This is made of sufficient capacity to keep the step bearing supplied with oil long enough to put the emergency pump into service.

Three reinforced concrete tunnels run at right angles to the turbine and at such a grade that they are always flooded, supply the circulating pumps. The discharge from each condenser is fed into a well, which connects to a common discharge tunnel, that empties into the river at a point south of the station.

PIPING.

In laying out the piping, the chief aim of the designers was so to design as to permit repairs of disabled lines without interfering with the regular service of the plant, to obtain simplicity and reliability. The general arrangement of piping depends in a great measure upon the space available for engines and boilers. In the layout the back to back arrangement was employed on account of the short and direct connection between engines and boilers.

Immediately below each boiler section the piper from the various boilers join the auxiliary headers, which feed into the main header. The main header extends the full length of the boiler room. Expansion is taken care of by expansion joints and the free ends

of the headers. Values are placed at various points in the pipe to allow sectionalizing. The headers leading to the turbines have long radius bends to provide for expansion. All the auxiliary apparatus is supplied with steam directly from the auxiliary header.

The boiler feed piping is laid out on the loop system with tie lines and value so that any part can be repaired without disabling the remainder. The main and auxiliary boiler feeds are fed by the main and auxiliary feed pump respectively. Two feed water heaters utilizing the exhaust steam of the auxiliaries are placed in the main boiler feed line. No economizers have been installed because of their unreliability and their effect on the chimney draft. The auxiliary line may be used for feeding boilers or supplying water for the station in case of fire.

SELECTION OF VOLTAGE AND FREQUENCY OF GENERATORS.

Aconsideration of distances between the generating station and substations, and the desire to make the cost of copper required in the system as low as possible led to the selection of a voltage of 9,000 both for the generators and the distribution system. The average distance between the generating station and the substations is about four miles. A voltage

of 9,000 may seem too high for this distance, but the possibility of supplying power to neighboring towns such as Ecorce, Wyandotte, Trenton and Gibraltar, and the desire to make the cost of copper required low justifies the use of this voltage. The construction of cable lines to the towns mentioned above would increase the average distance of distribution to about eight miles, and would greatly increase the cost of line cables. If the standard voltage of 6,600 were used for the generators, the cost of the generators, bus-bars, and cables would be almost double that for a voltage of 9,000. This is due to the fact that the amount of copper required for the lower voltage would be about 1.86 times as great as that required for 9,000 volts. Thus the use of a voltage higher than 6,600 seems desirable. The fact that the entire 25 cycle system of the Commonwealth Edison Company of Chicago is operated at 9,000 volts led to the determination of the exact voltage to be used.

The selection of a frequency of 25 cycles for all of the generators was governed mainly from the load curve shown on the enclosed blueprint. From this curve we see that there is a heavy peak in the morning which is evidently due to a power load. Moreover, Detroit is a great manufacturing city, the chief in-

dustries consisting of the manufacture of foundry and machine products, tobacco products, chemicals and drugs, malt liquors, Pullman cars, and automobiles. These industries require the use of a great number of motors and cause a large power load. The electric locomotives used in the tunnel connecting Detroit, with Winsdor furnish a heavy power load also. For these reasons it was decided to use 25 cycle generators entirely, and depend upon frequency-changers located in substations to supply the lighting load in outlying districts. In the more thickly populated residence and the factory districts the lighting load would be carried by the rotary converters which supply the power for the motor load.

EXCITATION.

Allowing one per cent. of the total station output for excitation gives 300 kilowatts required in exciters. The authors deemed it advisable to divide this capacity among four 75 kilowatt exciters in order to make the excitation system reliable and prevent a shut down of any unit in case of accident to one exciter. In order to keep the voltage across the exciter bus-bars absolutely constant, two 75 kilowatt storage batteries have been included in the excitation system. These batteries float on the exciter bus-bars at all times. In case of an accident to every one of the four

exciters these batteries could supply the excitation current until the exciters could be put into service again. In case of a complete shut-down of the plant due to some extraordinary disturbance, the two batteries could furnish power for 100 incandescent lamps distributed throughout the station. This would give enough light, enable the operating force to get the system into operation again. During such a shut-down the batteries could also supply power for the machine shop by being thrown on to the buses of the rotary-converter located in the substation in the switch-house. Thus any broken parts could be replaced and the plant put into operation again.

A further source of power for excitation is the 350 kilowatt rotary-converter located in the substation in the switch-house, as shown on the enclosed plan view drawing. This converter can be thrown on the exciter buses as shown on the enclosed blueprint of the excitation wiring. In this way a very reliable system of excitation is secured.

The rotary-converter mentioned above is intended to supply power for station lights, machine shop, and the various motors for operating the cranes, ventilating fans, coal and ash conveyors, coal crushers, stokers, fire-pumps, and etc. In case of a low tension

load growing up in the immediate vicinity of the station, there is enough room in the substation for another rotary converter to take care of the load. A more detailed account of the excitation system will be given under the next heading.

SELECTION OF SWITCH-HOUSE EQUIPMENT AND ITS ARRANGEMENT.

Following the standard practice for large central stations, the authors decided to locate all the bus-bars, control wiring, and switchgear in a separate building. In order to make all connections between the generators and bus-bars as short and direct as possible it was decided to build the switch-house up against the main building. This arrangement makes it possible, also, to have the operating gallery so located that an unobstructed view of the entire turbine room may be had from it. A general description of the switch-house arrangement is given below under the headings shown, and will help to explain the blueprints showing the plan view and end elevation of the switch-house.

BASEMENT OF SWITCH-HOUSE.

The basement is divided into three passageways extending parallel to the turbine room. These passageways are divided into rooms as described below. The passageway adjacent to the turbine room contains the

generator leads, generator field leads, storage battery leads, cables connecting the exciters to the exciter switchboards, and cables connecting the one exciter board to the other. Thus this passageway contains all of the low-tension cables.

The middle passageway contains two rooms in which are installed the storage batteries and their end-cell switches.

The third passageway contains all the high tension line cables. These cables are connected to bus-bars located on the first floor above and are led under-ground through conduits to the various substations. All cables are laid in vitrified tile conduits carried on racks made up of sheet and angle iron and encased in a heavy coating of concrete. No wood enters into the con-struction of the passageways, all walls and floors being made of concrete, and all doors of sheet steel.

FIRST FLOOR OF SWITCH-HOUSE.

The first floor is also divided into three passageways extending parallel to the turbine-room. The one next to the turbine-room contains the gener-ator buses, the main and auxiliary high tension buses, the current and potential transformers for the meters on the generator control panel in the operating gallery, and the terminal boards, such as No. 5, shown

on the Control Wiring blueprint.

The main and auxiliary high tension buses are mounted on horizontal shelves as shown on the blueprint showing the end elevation of the plant. These shelves are fastened to the west wall of the passageway and are seven in number. The main buses are mounted on shelves number 2, 3 and 4, and the auxiliary buses on shelves number 5, 6 and 7. These bus-bars are fed from the three generator leads, each one of which is connected to one main and one auxiliary bus-bar through a type H 3 vil switch located on the second floor above.

The middle passageway contains the leads connecting the generator leads to the main and auxiliary high tension bus-bars through the oil-switches, the line bus-bars, the leads from the main and auxiliary high tension bus-bars which terminate at the line oil switches, one single phase potential transformer for each section of the main buses, one single phase potential transformer for the auxiliary buses, and terminal boards such as Nos. 3 and 4, as shown on the control wiring blueprint.

The third passageway contains the leads from the line oil switches, which connect the line buses to the main and auxiliary buses, the individual line leads, which are connected to the cables in the third

passageway of the basement, the current and potential transformers for the individual lines, the ground buses for these transformers and for the lead sheath of the line cables, and such terminal boards as Nos. 1 and 2, as shown on the control wiring blueprint.

The two walls which divide the first floor into three passageways, are twelve inches thick and are made of concrete. All bus-bar shelves, ceiling barriers, and barriers separating the oil switch leads from one another, etc., are made of a special insulating compound called "Elecrete". This compound is made into slabs and shelves just as concrete would be, and makes the slabs and shelves have a very smooth surface and a uniform texture throughout. The compound is made by the Garden City Sand Company of Chicago, and is sold to central station companies. The latter then send the bags of compound to the contractors, who are to make the slabs, shelves and barriers. The finished barriers, etc., have an orange color, and are much more easily dulled, cut, etc., than concrete is. In them are laid the conduits which contain the wires from the secondaries of the current and potential transofrmers which lead to the terminal boards. Those conduits which carry the control wires from the terminal boards to the operating gallery are laid in the two concrete

walls mentioned above. The terminal boards themselves are enclosed in casings of one-half inch asbestos board. Thus all the control wires are laid either in the elecrete barriers or in the concrete walls and cannot be injured by any short circuit on the bus-bars. If the secondaries of the transformers should burn out, or if a short circuit on the bus-bars should destroy entirely the instrument transformers and the short lengths of exposed control wires, the latter need be replaced as far as the terminal boards only, thus facilitating repairs to damaged bus-bars and transformers. Furthermore, when meter transformers are to be tested, the work can be done entirely from the terminal boards, which are removed from all high tension bus-bars. This facilitates testing of the transformers and makes it unnecessary to work near high tension parts.

In the south end of the first floor is a room used as a machine shop. This contains all the lathes, drill-presses, planers, shapers, etc., which are necessary in order to make parts of machines, motors, etc., for repair work. The power for this machine shop is taken from the substation bus-bars.

In the north end of the first floor is the

substation which contains a 350 kilowatt rotary converter and its transformers and switchboard. As stated above, this converter supplies power for the lights and motors used in the station, and may, further, be used for excitation purposes in case the exciters fail.

No wood is used in the construction of this floor, all walls and floors being made of concrete, and doors of sheet steel. To prevent a short circuit from spreading to other parts, asbestos board covers are fastened to all of the shelves upon which the main, auxiliary and line buses are mounted. In the three passageways containing the high tension bus-bars there are no windows, this arrangement being adopted in order to make it impossible for dirt to fly in from the outside and cause short circuits on high tension parts, and to prevent inquisitive persons from entering the bus-bar passages and touching high tension buses.

SECOND FLOOR OF SWITCH-HOUSE.

The greater portion of the second floor is given up to the type H 3, motor-operated, oil switches. These are arranged in two rows parallel to the turbine room. The row nearest the turbine room is made up of group switches. These connect the generator leads to

the main and auxiliary buses and the main and auxiliary buses to the line buses, and tie the sections of the main buses together. The second row of oil switches connect the individual feeder lines to the line buses.

At the south end of this floor is a room located above the machine shop, which may be used as a construction shop. At the north end of this floor, is another room, located above the substation, which may be used as a construction shop also, or as a storeroom.

In the oil-switch rooms, and built next to the turbine-room, is a conduit room, four feet wide. All conduits containing control wires, in leading from the terminal boards on the first floor to the operating gallery on the third floor pass through this room. They are put in a separate room in order to prevent any disturbance in the oil switch room from affecting in any way the conduits.

On the west wall of the oil switch room are mounted five signal boards, one for each generator, each of which has mounted upon it eight lamps, each connected to C phase of the secondaries of the potential transformers connected to the feeder lines. These lamps indicate which lines are alive and which dead.

THIRD FLOOR OF SWITCH-HOUSE.

This floor does not extend the entire length

of the switch-house, being only 60 feet long, and located at the center of the building. It is devoted entirely to the operating gallery, and offices for the chief electrician, tester, engineer and operator. The operating gallery is a room 20 ft.x60 ft. It contains all the alternating control panels, which consist of the following:- one battery and exciter control panel, five generator control panels, and forty line control panels; the battery and exciter control panel, and the generator control panels are of the bench-board type, and are placed near the curved window overlooking the turbine room. The line control panels are of the ordinary standard type, and are placed near the west wall of the operating gallery.

All of the panels in the gallery are made of two inch black slate. The arrangement of the instruments upon them is shown on the enclosed blueprint of the alternating current control panels.

No wires having a potential greater than 125 volts are brought to the switchboards. Moreover, no high tension cables, or bus-bars are led through the operating gallery. This arrangement simplifies the switchboard arrangement and insures reliable operation on the part of the attendants. This last fact

is of great importance, especially in the case of a short circuit or disturbance, when clear headedness on the part of the operators is absolutely essential. A further advantage of this arrangement is the fact that no disturbance in the high tension bus-bars or switches can spread to the operating gallery or injure the expensive switchboard instruments.

Let us now discuss in detail the high tension cables, bus-bars and switchgear, the measuring instruments with their transformers, the control wiring, etc., for one generator. Starting at the armature of the generator, we have six brass pipes, each 2 inches in diameter, which contain the three armature leads, the generator neutral cable, and the two field cables. These cables are made of a large number of small wires and are thus quite flexible, making it easy to draw them through the brass pipes. They are insulated with varnished cambric covered with a layer of black braid. They terminate in a terminal box placed on the turbine-room floor close to the ventilating duct. Here they are connected to lead covered, paper insulated, single conductor cables. About each joint is placed a cable bell, which is filled with an insulating compound called "Minerallac". The three generator leads have a cross-section of 1,000,000 circular mils, the neu-

tral lead is made of 0000 B & S gauge cable, and the field leads each have a cross section of 1,000,000 circular mils.

From the above mentioned terminal box, the six lead covered cables are carried on a cable rack made of sheet and angle iron, and suspended about three feet from the ceiling of the turbine room basement. Near the west wall of this basement is led through the neutral current transformer, then through the non-inductive resistance shown on the blueprints, and then through the neutral oil-switch. This oil-switch is solenoid operated, type K 2, and is set close to the wall. After passing through this oil-switch, the neutral cable is connected to the main ground bus. This bus is made of four inch by one-fourth inch copper, and is run along the west wall of the turbine room basement. It is bolted firmly to every steel column along the wall and is also connected to two large ground plates, which are buried in the ground in the midst of a mass of coke.

The generator leads and the field leads pass through the west wall of the turbine room basement. The generator leads are led along the other side of this wall on a cable rack and then up to the spaces between the vertical barriers provided for them in

the east passageway on the first floor. Here the leads terminate in cable bells, where each is connected to a two inch by one-half inch copper bar.

The two field cables are led along on a cable rach immediately beneath that carrying the generator cables, and when beneath the proper panel on one of the exciter switchboard pass upward, one going directly to one point of the double pole, solenoid operated generator field switch, and the other through the generator field rheostat to another point of the generator field switch. The two remaining points of the generator field switch connect to the exciter bus-bars.

Let us now return to the terminal bells where the generator leads terminate. Located against the east wall of the east passageway on the first floor are five sets of vertical elecrete barriers, seven in each set, each generator having one set. Their arrangement is shown on the enclosed blueprint, showing the plan view of the station. The three generator leads terminate in three cable bells located in spaces one, two, and three. At each bell a copper bar, two inches by one-half inch in cross section, connects to the lead covered cable coming from the cable passage in the basement. The bells are made of vitrified tile, and are filled with "minerallac" in

order to protect the joint. Immediately below this bell, the lead sheath is grounded through a one inch by one-fourth inch copper bar connected to the main ground bus in the basement of the turbine room.

Each two inch by 1/2" copper bar, which is connected to its lead covered cable, is led through a current transformer, as shown on the enclosed blue-print of the high tension buses. A potential trans-former is connected between each bar and the one inch by one-quarter inch ground bus on the high tension side. Both ends of the low tension side are connected to a ground bus, insulated from the one mentioned above, and called the "instrument ground bus". The potential transformers are set on the floor in spaces 4, 5 and 6. Immediately above them are places for potential fuses, which are in the high tension circuits of the potential transformers. The electri-cal connections of these current and potential trans-formers are shown on the control wiring blueprint.

From the three terminal bells mentioned above the three generator leads pass upward to three short generator-buses mounted on horizontal shelves near the ceiling. From these buses six copper leads, each two by one-half inch in cross-section, connect to two

group oil switches. From these switches three of the leads connect to the main buses, and three to the auxiliary buses. From each section of the main buses six copper leads, each two by one-half inch in cross-section pass up to two of the group oil switches. From one of these switches three of the leads connect to the north line buses, and from the other, three connect to the south line buses. To each set of line buses are also connected three leads, which tie these buses to the auxiliary buses. Each generator has two sets of line buses, as shown on the blueprint of the high tension bus-bars. Each set of line buses feeds four lines, the leads for which pass from the buses to the line oil switches and thence through the current transformers to the lead covered line cables.

Estimate of Total Cost of Station.

In making an estimate of the total cost of the station,the authors consulted the reports of various central station companies,and also a number of books bearing on the subject.The following estimate includes only the cost of constructing the station and does not consider the cost of the site or coal storage yards. The figures given below are quite conservative, and, with careful engineering could be reduced.

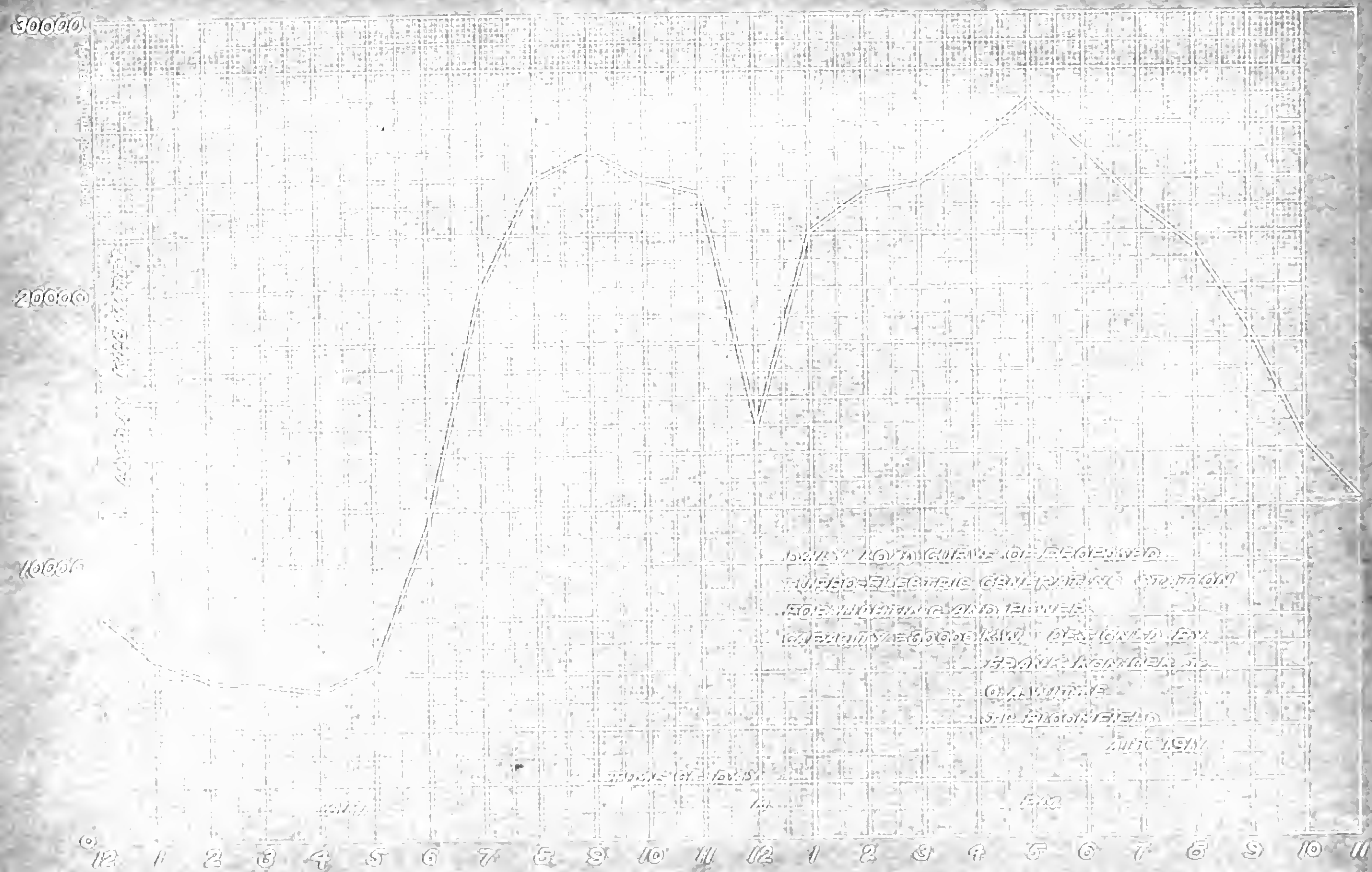
Cost in Dollars per Kilowatt.

Excavation and foundation	2.25
Superstructure	12.50
Condensing-water Tunnel	2.75
Flues and Chimney	3.00
Boilers and Stokers	10.50
Superheaters	2.25
Feed-water Heaters	2.00
Coal and Ash Conveyors	2.25
Pumps	1.25
Piping	3.50
Turbo-Generators	23.50
Surface Condensers	8.50
Switchboard	2.75
Exciters	.75
Cranes	.25

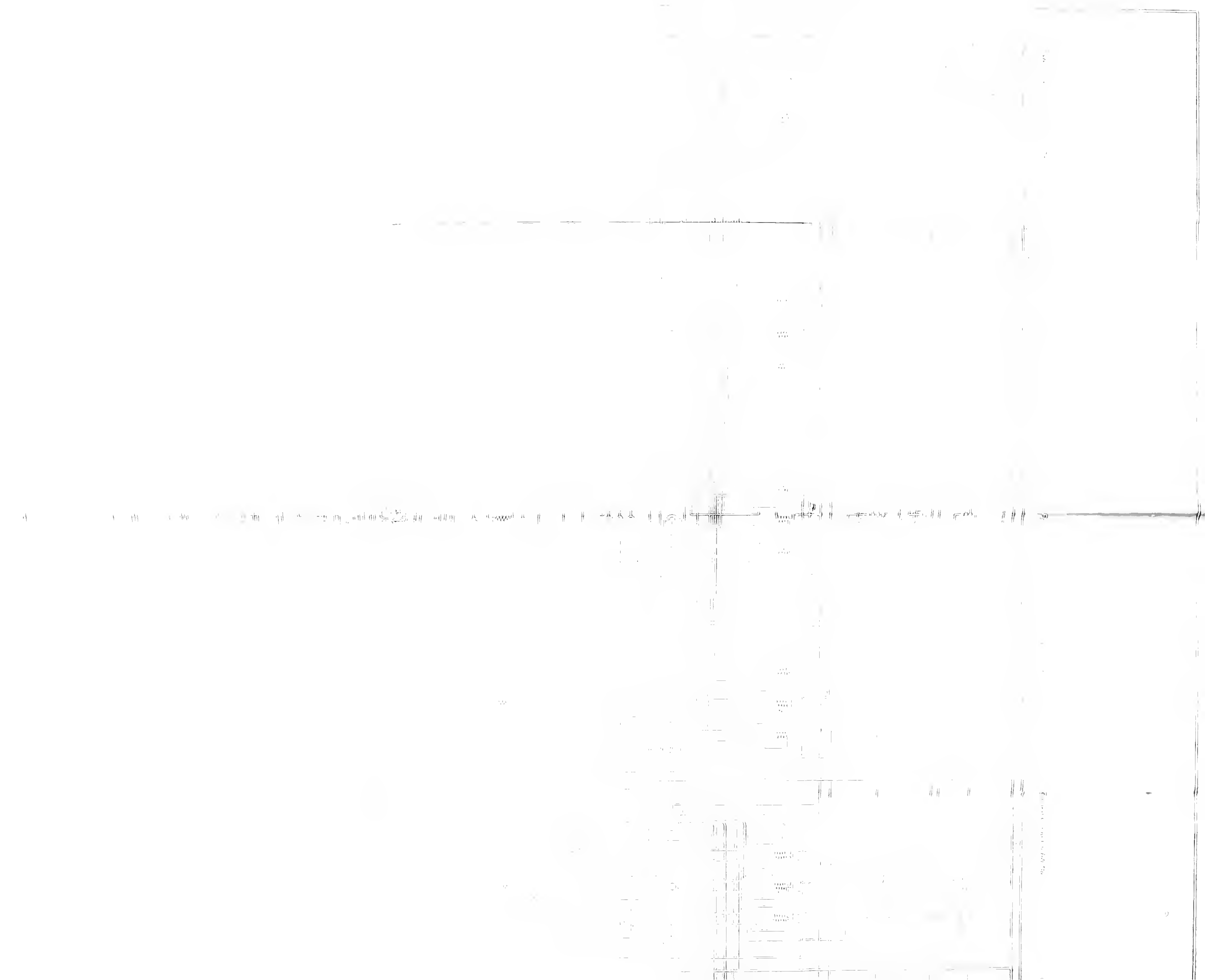
Miscellaneous................................	1.00
	79.00

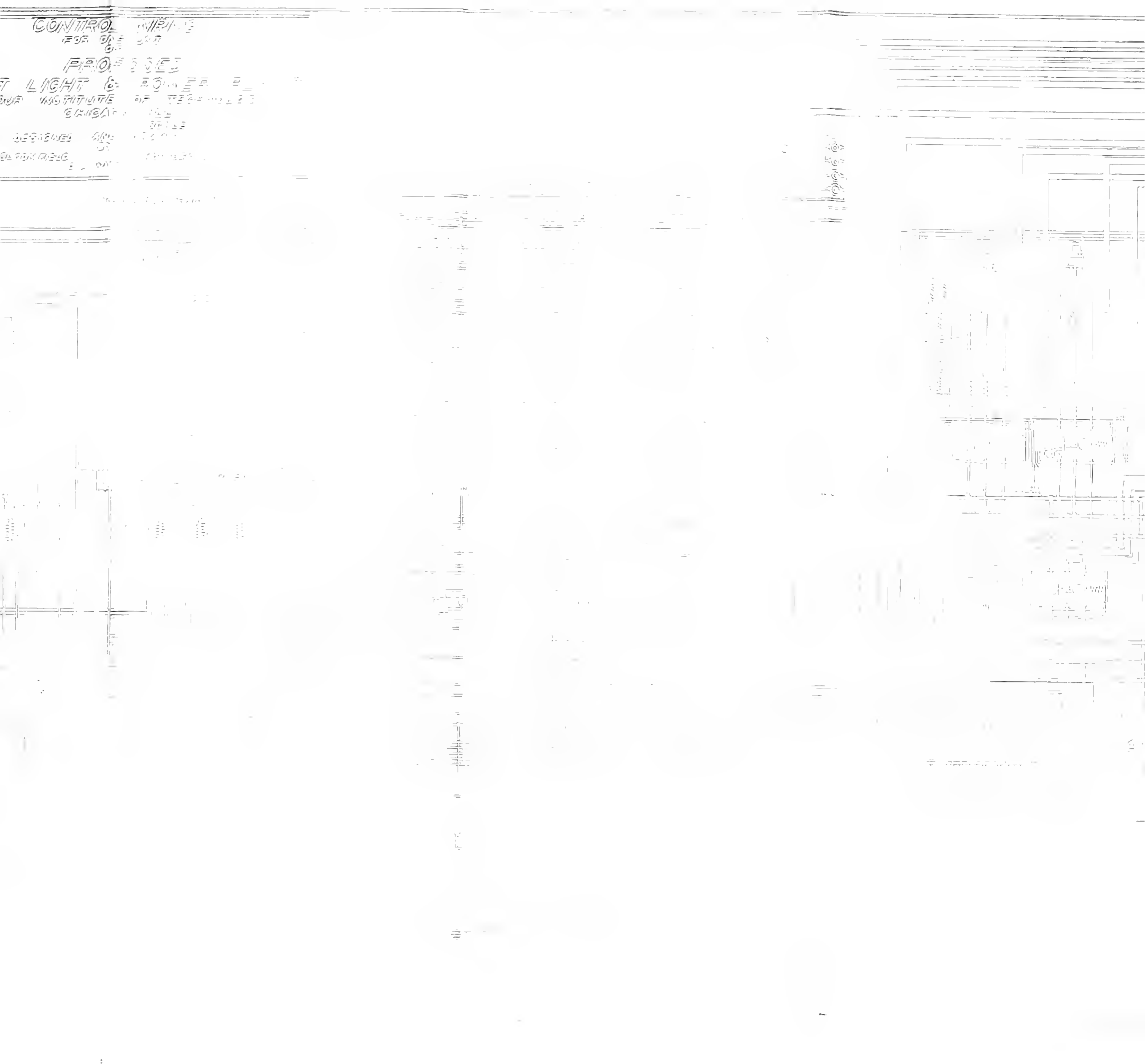
The total cost of construction will therefore be 30,000 x $79.00= $2,370.000.

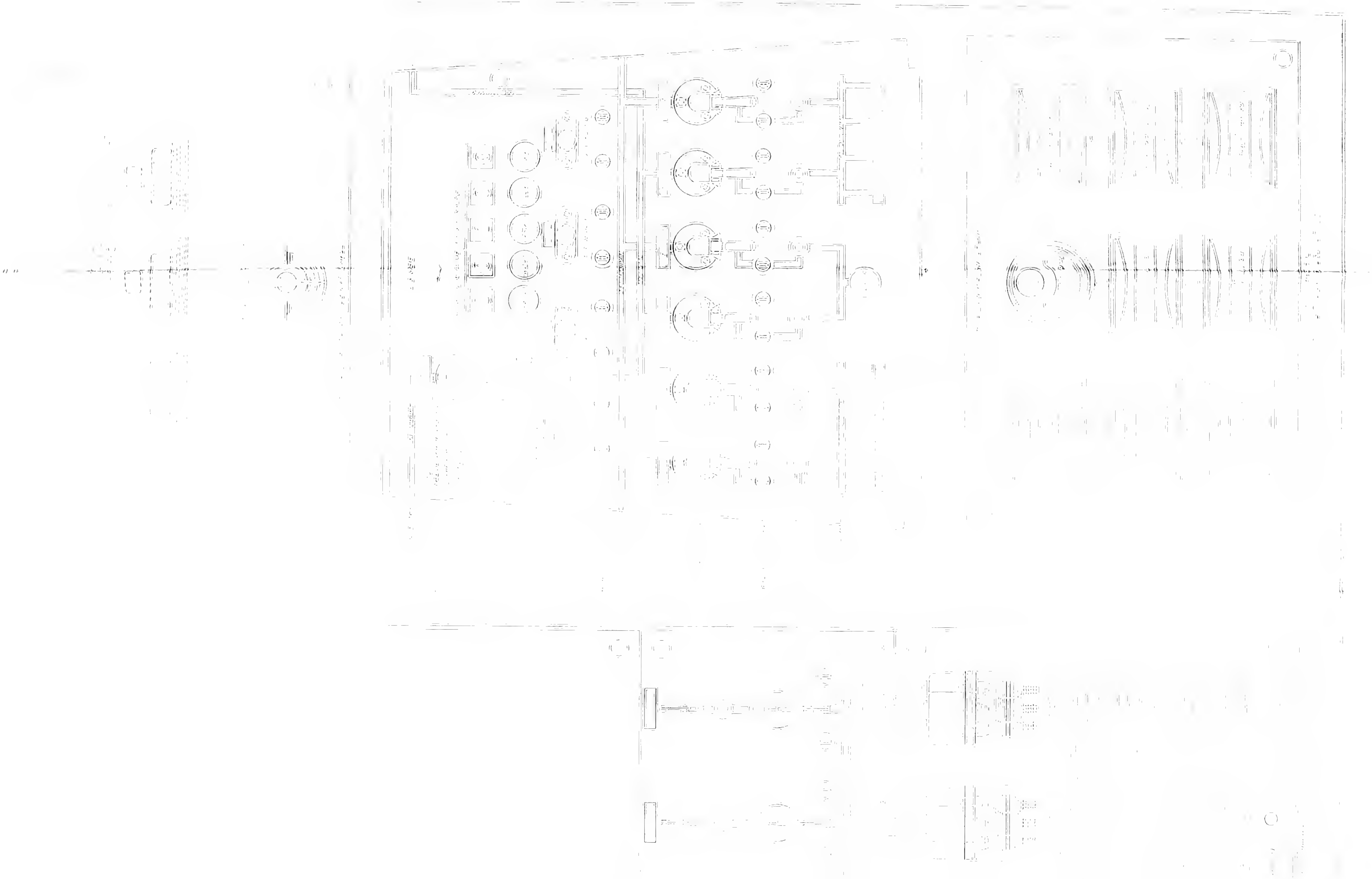
The above figures are, of course, only rough approximations, since they are not based upon actual quotations of pricesof machinery, etc. The authors believe, however, that they are within 5% of what would be realized if the station were actually constructed.

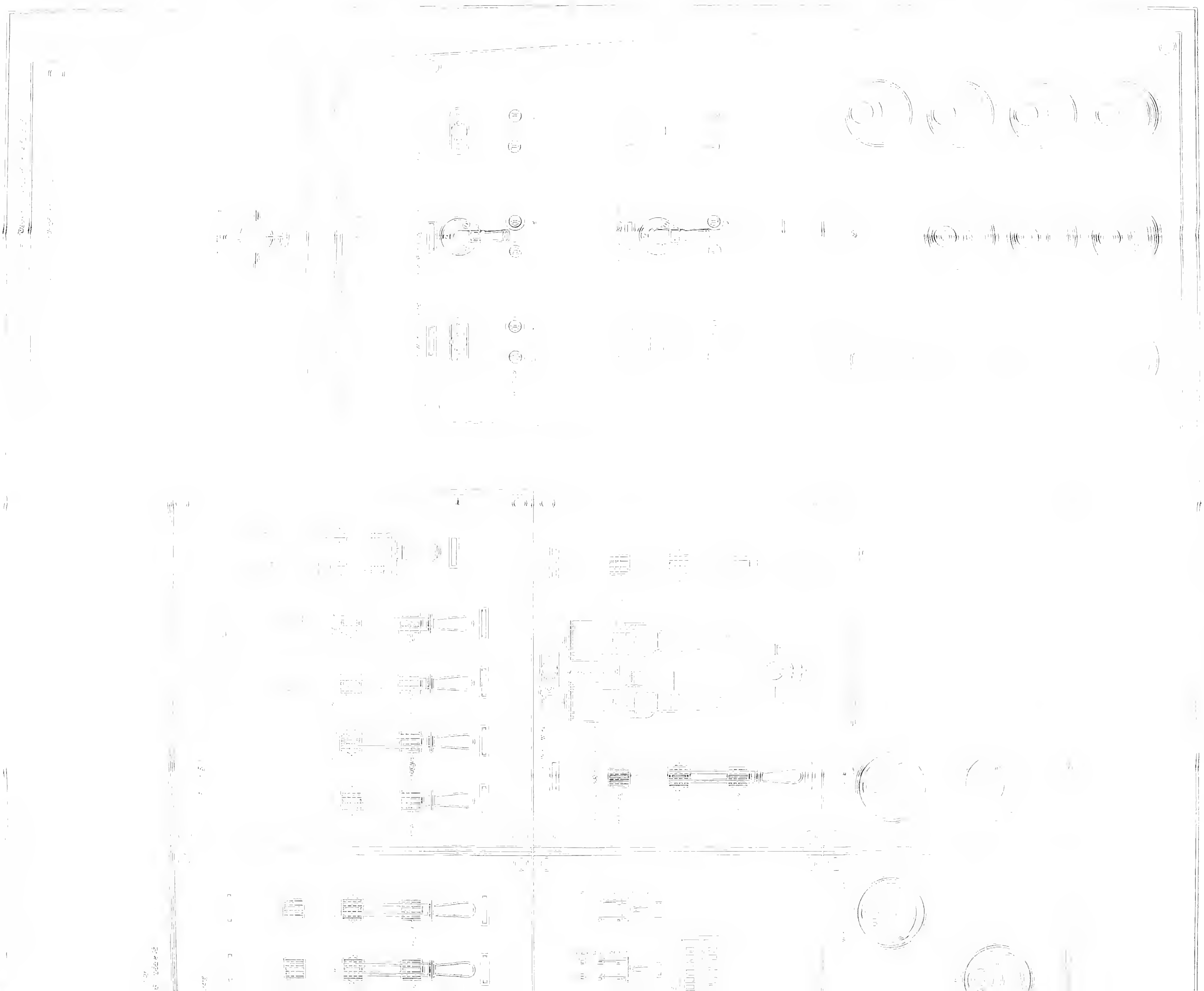


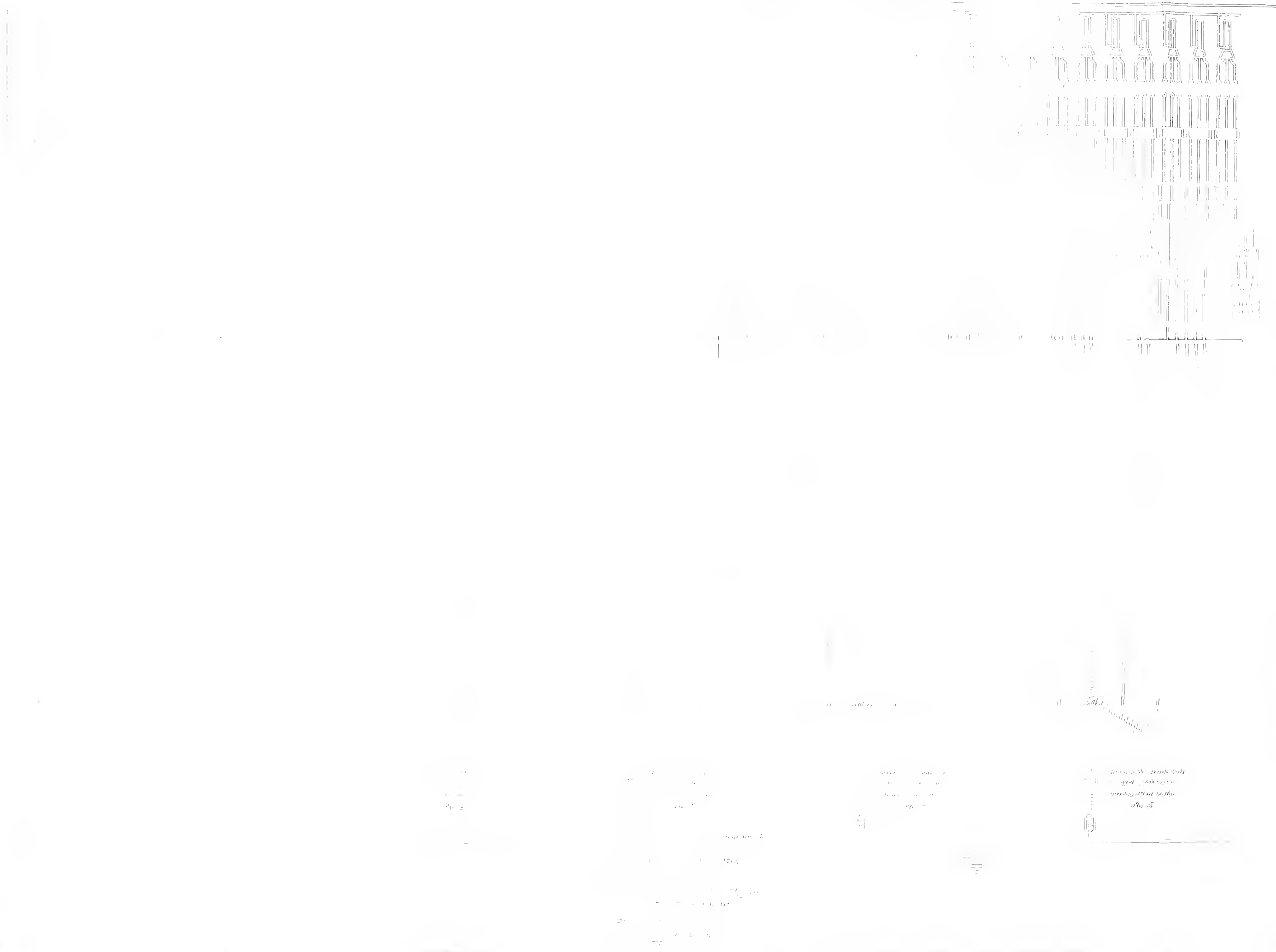
30000
20000
10000
DAILY LOAD CURVE OF PROPOSED
TURBO-ELECTRIC GENERATING STATION
FOR LIGHTING AND POWER.
CAPACITY = 60000 K.W. DESIGNED BY
TIME OF DAY
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11

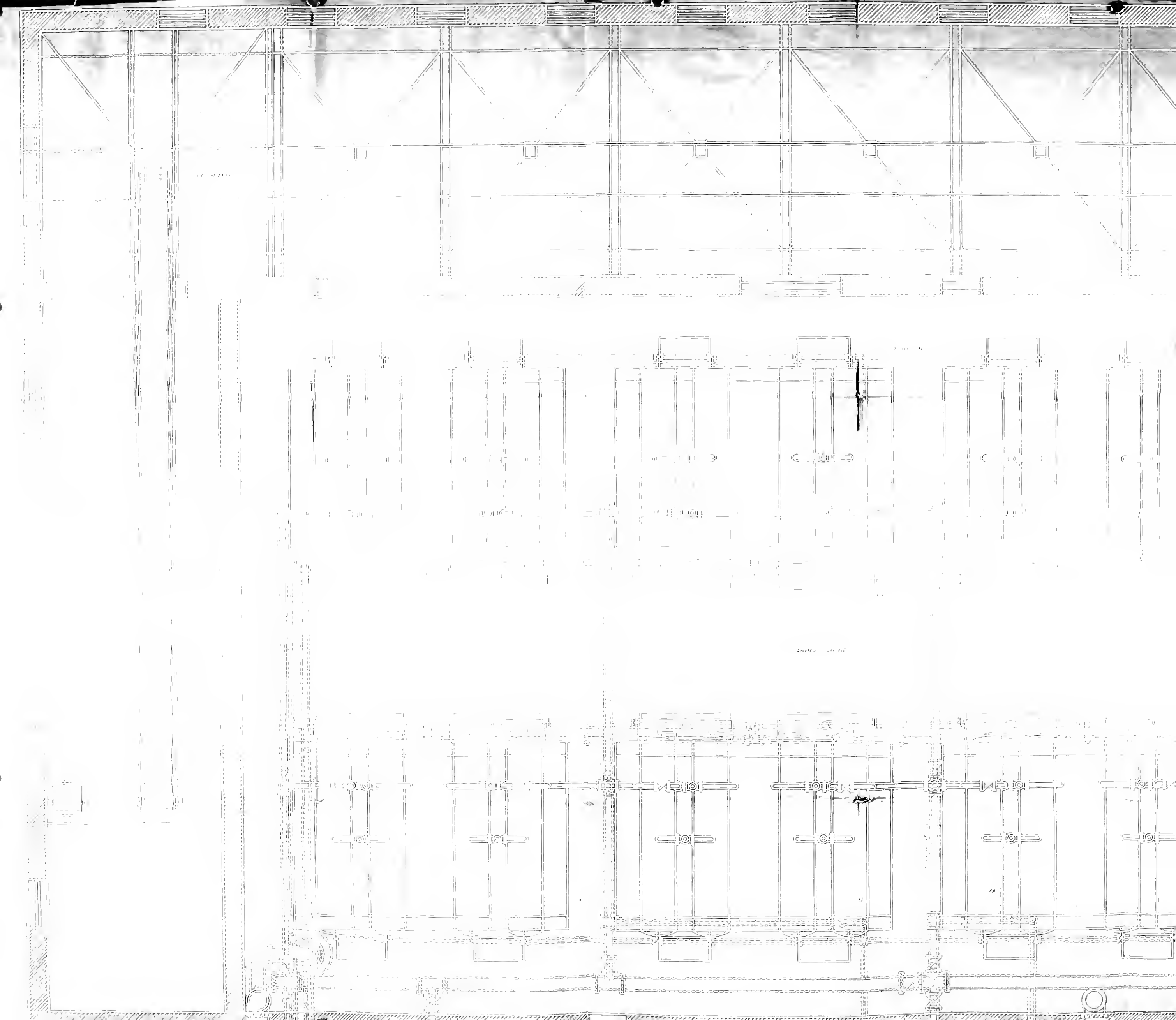


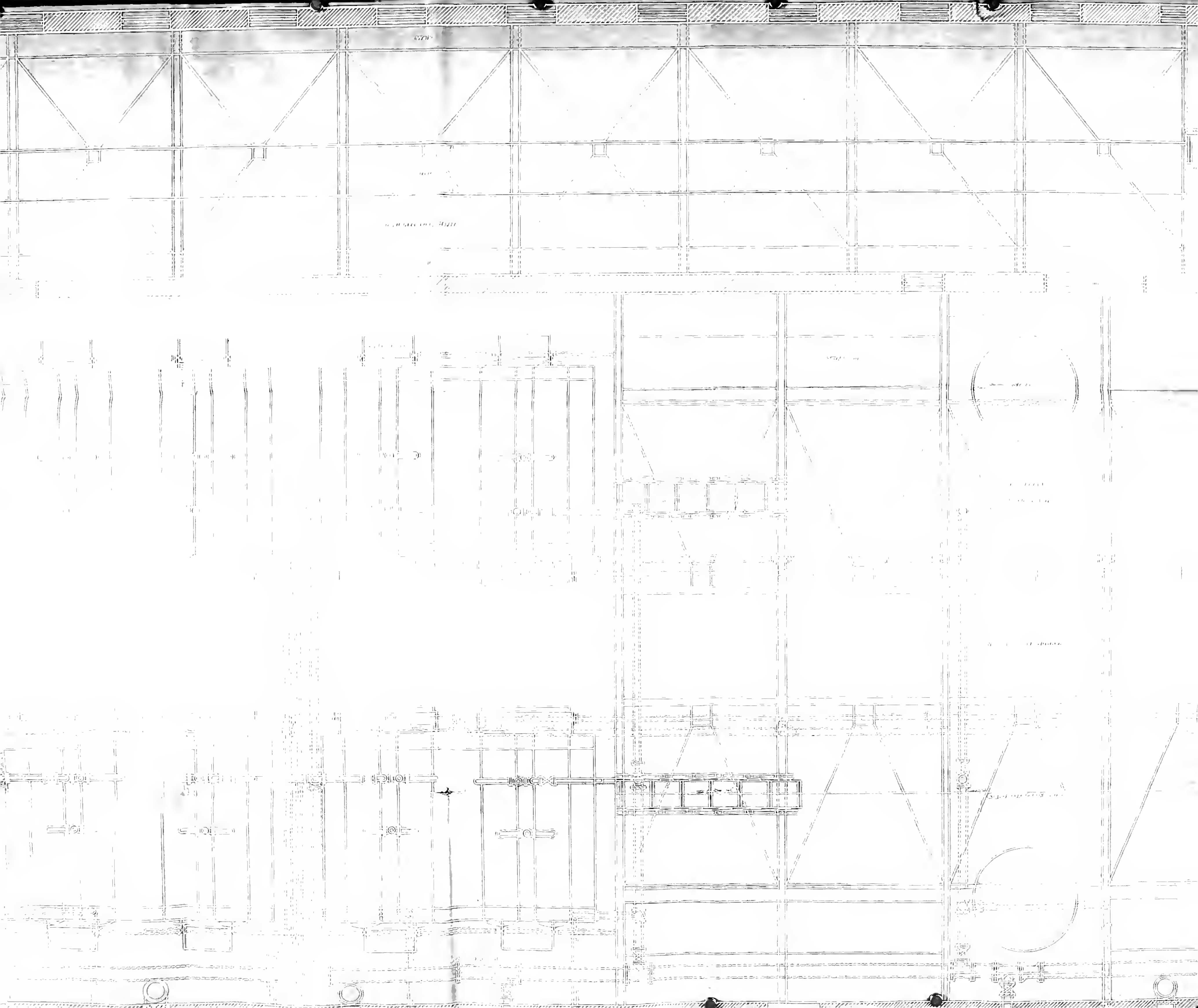

CONTROL
PRO
LIGHT &
INSTITUTE OF
DESIGNED

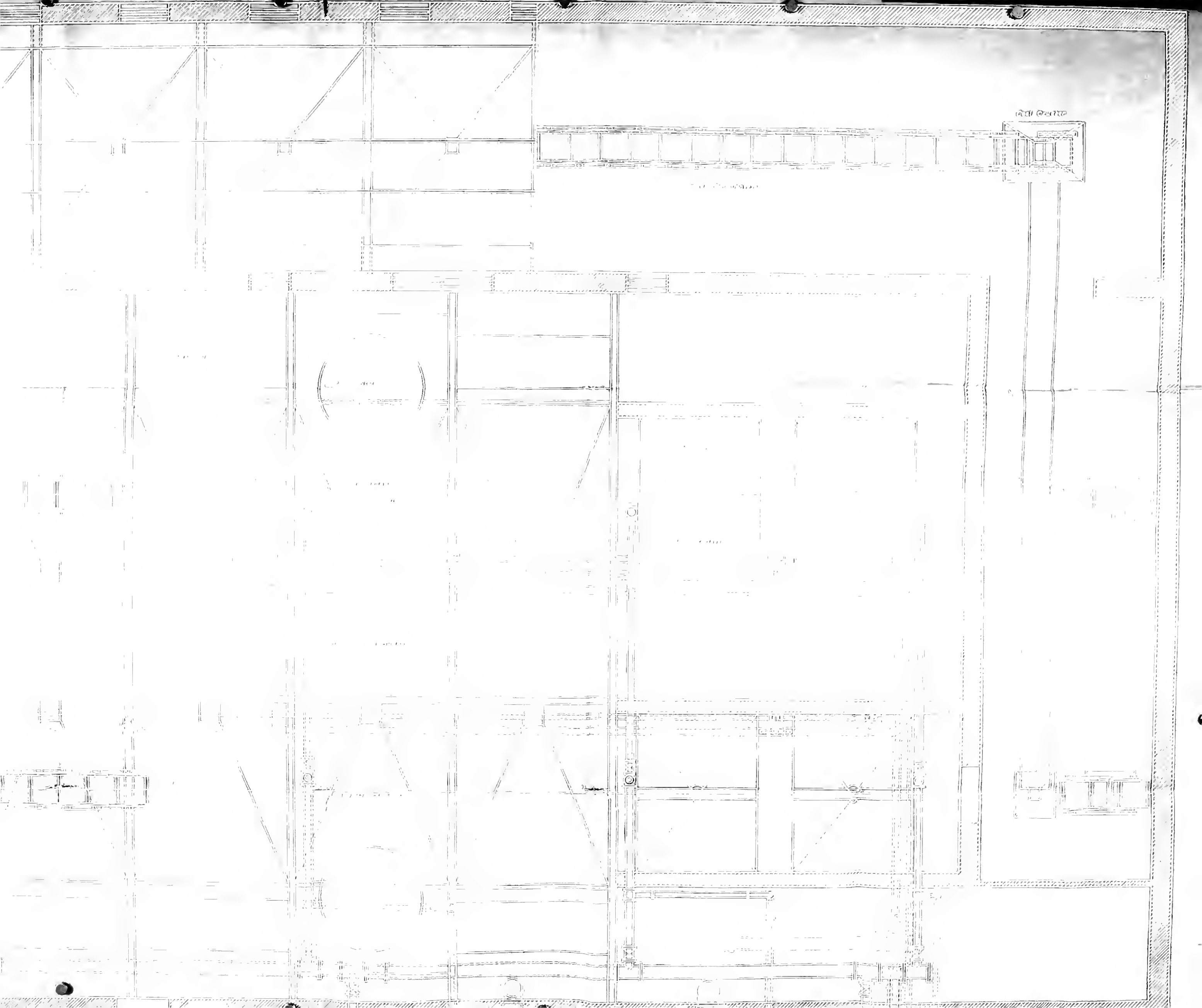


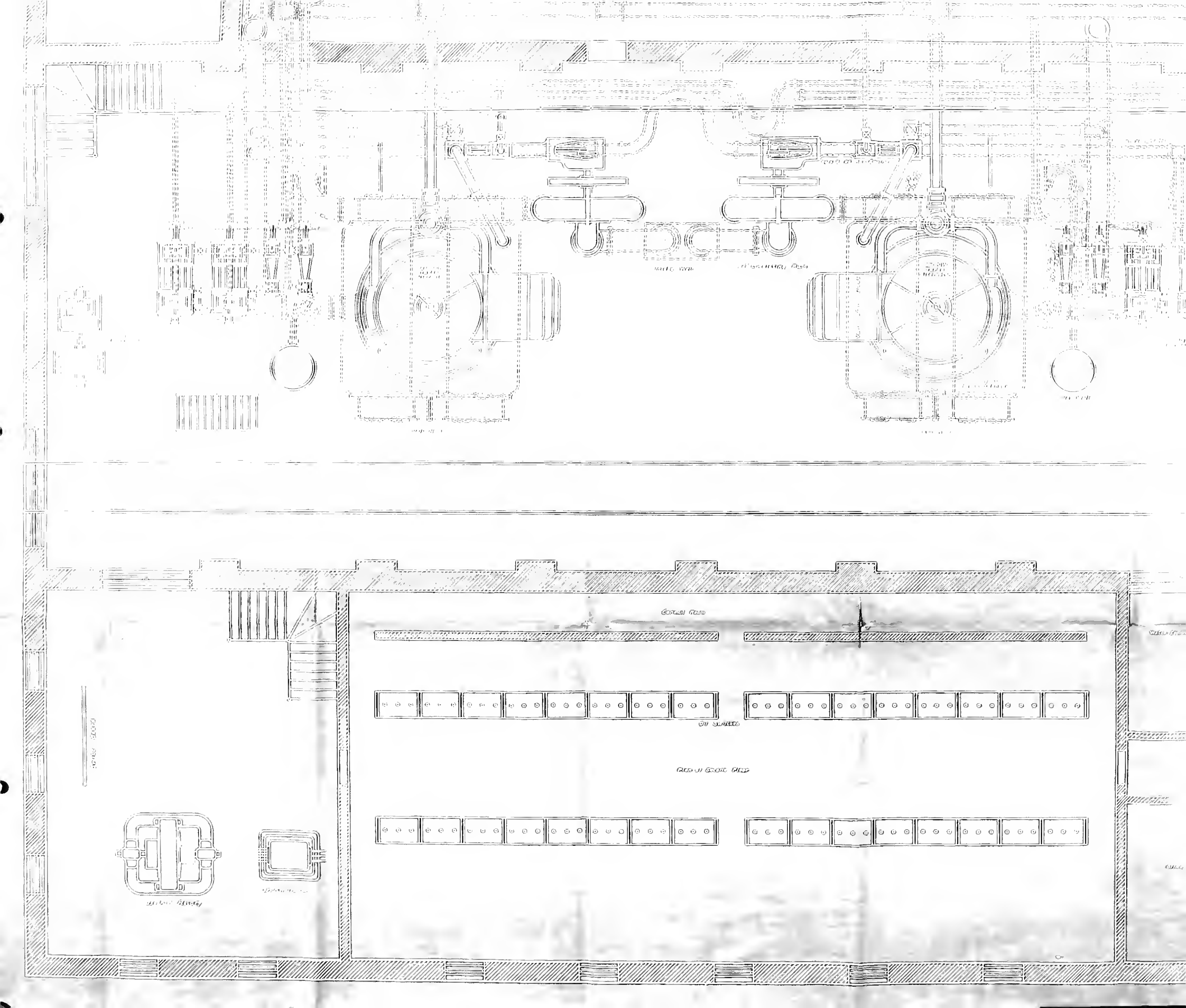


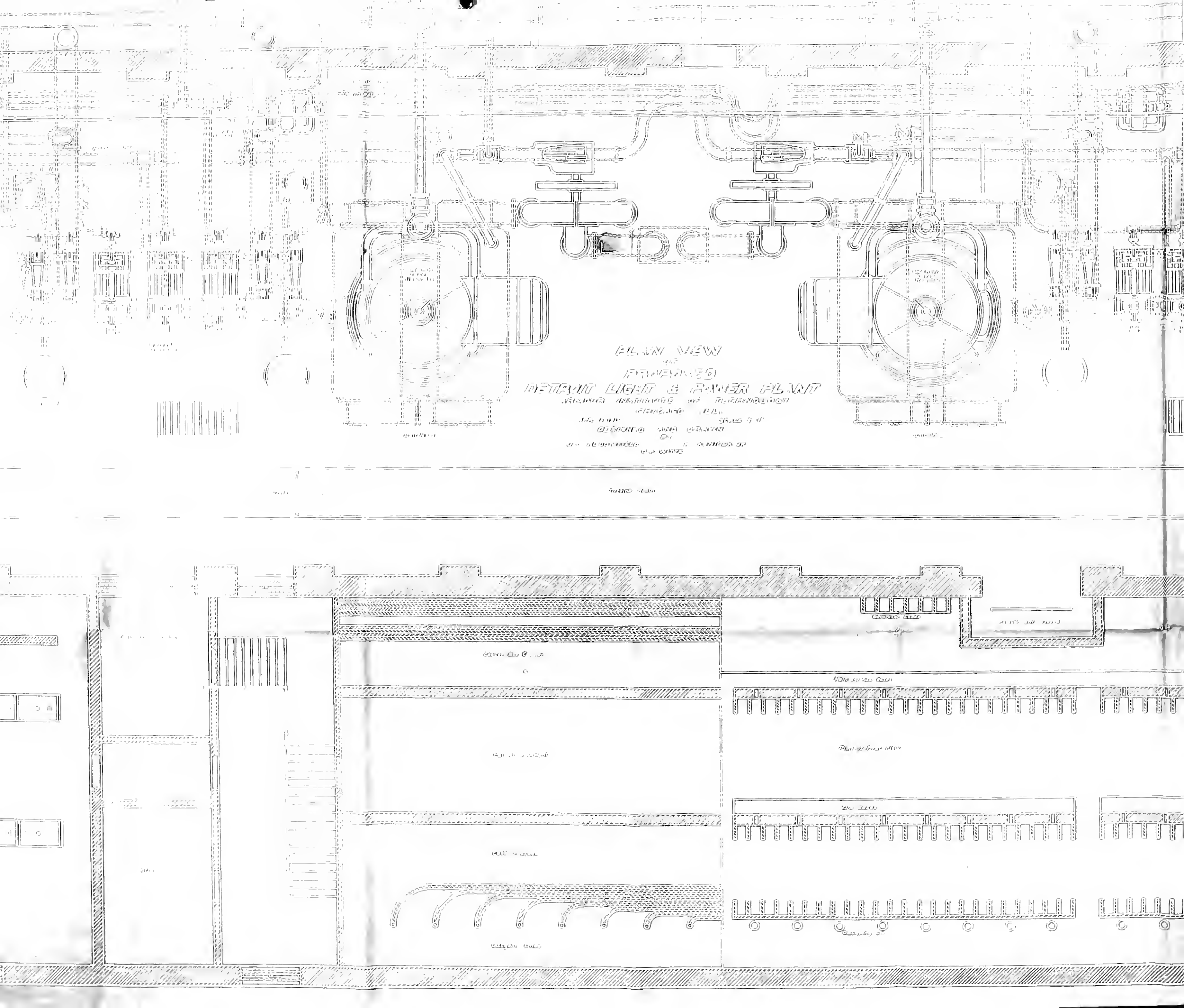












PLAN VIEW
OF
PROPOSED
DETROIT LIGHT & POWER PLANT
ARMOUR INSTITUTE OF TECHNOLOGY
CHICAGO ILL.
DESIGNED AND DRAWN
BY